
UNIT 2 SOIL

Structure

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2.0 INTRODUCTION

Soil is the third basic component of the nature, besides air and water. Soil is technically defined as the layer of unconsolidated particles derived from weathered rocks, organic material, water and air that supports plant growth. Soil provides a medium in which an amazing variety of organisms live. Soil plays critical role to sustain life in terrestrial environment. Since human is terrestrial creature and largely dependent on land based food resources, his survival on the planet, to a great extent depends on maintenance of fertility of soil to grow enough food for the huge population. Soil fertility connotes the ability of soil to supply nutrients for plant growth and is governed by numerous biophysical factors including type of management applied.

The present unit aims at building basic understanding about soil and its different attributes. In order to build perspective about soil system, the unit is based on the basic concept of soil science and soil ecology. Attempts have been made to simplify the technical description of the subject.

2.1 OBJECTIVES

After reading this unit, you will be able to:

- describe and discuss the concept of soil and its formation;
- discuss components and fertility attributes of soil; and
- explain the sustainability issues associated to soil.

2.2 CONCEPT OF THE SOIL

Soil forms a thin layer over the Earth's surface and acts as the interface between the atmosphere and lithosphere. It is a multiphase system, consisting of mineral material, soil organisms, plant roots, water, gases and organic matter at various stages of decay. The soil scientists define soil as "a natural body, synthesized in profile form from a variable mixture of broken and weathered minerals and decaying organic matter, which covers the earth in a thin layer and which supplies, when containing the proper amounts of air and water, mechanical support and, in part, sustenance for plants". Webster's New Universal Unabridged Dictionary describes soil in the simplest way as "the upper layer of earth, which can be dug or plowed and in which plants grow."

Soil means different things to different users. For example, to the geologist and engineer, the soil is little more than finely divided rock material. The hydrologist may see the soil as a storage reservoir affecting the water balance of a catchment, while the ecologist may be interested only in those soil properties that influence the growth and distribution of plants and animals. The farmer is naturally concerned about the many ways in which soil influences crop growth and the health of his livestock, although frequently his interest does not extend below the depth of soil disturbed by a plough (15–20 cm).

Soil is a natural body consisting of layers (soil horizons) of mineral constituents of variable thicknesses, which differ from the parent materials in their morphological, physical, chemical, and mineralogical characteristics. Soil, strictly speaking, is a weathered rock material and packed loosely with organic matter, forming a soil structure filled with pore spaces. These pores contain soil solution (liquid) and air (gas). Accordingly, soils are often treated as a three state system. Most soils have a density between 1 and 2 g/cm³. Soil is also known as earth: it is the substance from which our planet takes its name. Little of the soil composition of planet Earth is older than the Tertiary and most of the soil composites on us no older than the Pleistocene. In engineering, soil is referred to as regolith, or loose rock material.

The soil also provides a medium in which an astounding variety of organisms live. These organisms not only use the soil as a habitat and a source of energy, but also contribute to its formation, strongly influencing the soil's physical and chemical properties and the nature of the vegetation that grows on it. Indeed, along with vegetation, the soil biota is one of five interactive soil forming factors: parent material, climate, biota, relief, and time.

2.3 HISTORICAL PERSPECTIVE

Human's use of soil for food production began two or three thousand years after the close of the last ice age, which occurred about 11,000 years before present. Neolithic people and their primitive agriculture spread outwards from settlements in the fertile crescent embracing the ancient lands of Mesopotamia, Canaan and southern Turkey and reached as far as China and the Americas within a few thousand years. In China, for example, the earliest records of soil survey (4000 years before present) show how soil fertility was used as a basis for levying taxes on landholders. To study the soil was a practical exercise of everyday life,

and the knowledge of soil husbandry that had been acquired by Roman times was passed on by peasants and landlords, with little innovation, until the early 18th century.

19th century was the period of great discoveries in physics and chemistry, the implications of which largely influenced agriculture. In 1840, Von Liebig established that plants absorbed nutrients as inorganic compounds from the soil, although he insisted that plants obtained their nitrogen (N) from the atmosphere. Lawes and Gilbert at Rothamsted, subsequently demonstrated that plants (except legumes) absorbed inorganic N from the soil. During the years from 1860 to 1890, eminent bacteriologists including Pasteur, Warington and Winogradsky elucidated the role of microorganisms in the decomposition of plant residues and the conversion of ammonia to nitrate. Over the same period, botanists such as Von Sachs and Knop, identified the major elements that were essential for healthy plant growth. That time, the soil was regarded as a relatively inert medium providing water, mineral ions and physical support for plants.

Up to mid of the twentieth century, more and more land was brought into cultivation, much of which was marginal for crop production because of limitations of climate, soil and topography. Since 1950s, demand for food, fiber and forest products from an escalating world population (now > 6 billion) has led to increased use of fertilizers to improve yields, and pesticides to control pests and diseases. More recently, however, scientists, producers and planners have acknowledged the need to compromise between maximizing crop production and conserving a valuable natural resource. Emphasis is now placed on maintaining the soil's natural condition by minimizing the disturbance, when crops are grown, matching fertilizer additions more closely to crop demand in order to reduce losses, using legumes to fix N₂ from the air, and returning plant residues and waste materials to the soil to supply some of a crop's nutrient requirements.

2.4 SOIL FORMATION

Soil formation is a very long process. A combination of physical, chemical and biotic forces acts on weathered rock and organic materials to produce soil through the process of pedogenesis. It begins with the weathering of rocks into small fragments. The rocks are also worn away by the agents of erosion like river, wind, sea and glacier. The sediments and tiny rock particles are then deposited by the agents of erosion. The accumulation of such sediments over the ages forms soil. Eventually, the plants that grow on the soil, shed their leaves which decay to form the topmost layer of soil called 'humus'.

Soils are formed by the weathering of in situ consolidated rock, or unconsolidated superficial deposits which have been transported by ice, water, wind or gravity. Consolidated rocks are of igneous, sedimentary or metamorphic origin. Igneous rocks are formed by the solidification of molten magma in or on the Earth's crust, and are the ultimate source of all other rocks. Sedimentary rocks are composed of the weathering products of igneous, metamorphic and older sedimentary rocks, and are formed after deposition by wind and water. Igneous and sedimentary rocks that are subjected to intense heat and great pressures are transformed into metamorphic rocks.

Most parts of the Earth's surface have undergone several cycles of submergence, uplift, erosion and denudation over hundreds of millions of years. During the mobile and depositional phases there is much opportunity for materials from different rock formations to be mixed, and soil genesis on heterogeneous parent material. Soils are the result of the interactions of several factors e.g. climate, organisms, parent material, and topography (relief) all acting through time. These factors affect major ecosystem processes (e.g., primary production, decomposition, and nutrient cycling), which lead to the development of ecosystem properties unique to that soil type, given its previous history. Thus such characteristics as cation exchange capacity, texture, structure, organic matter status, etc., are the outcomes of the aforementioned processes, operating as constrained by the controlling factors. Different arrays of processes may predominate in various ecosystems.

2.5 SOIL PROFILE

Digging down through the soil, one comes across a series of layers of different colours, compositions and physical properties. The number of layers and thickness of each vary across the regions. These layers are called soil horizons and vertical pattern of these layers is called soil profile. From top to down, O, A, B and C horizons are observed in most of the soils. In the forest soil or wherever organic matter is found in good amount, there are three layers above the A-horizon. These are litter (L), fermentation (F), and humification (H) zones (Oi, Oe, and Oa, respectively). These are collectively called top soil. These layers are, in fact, soil organic matter in various stages of decomposition and hardly contain mineral soil. Majority of the biological and chemical activities occur in these layers.

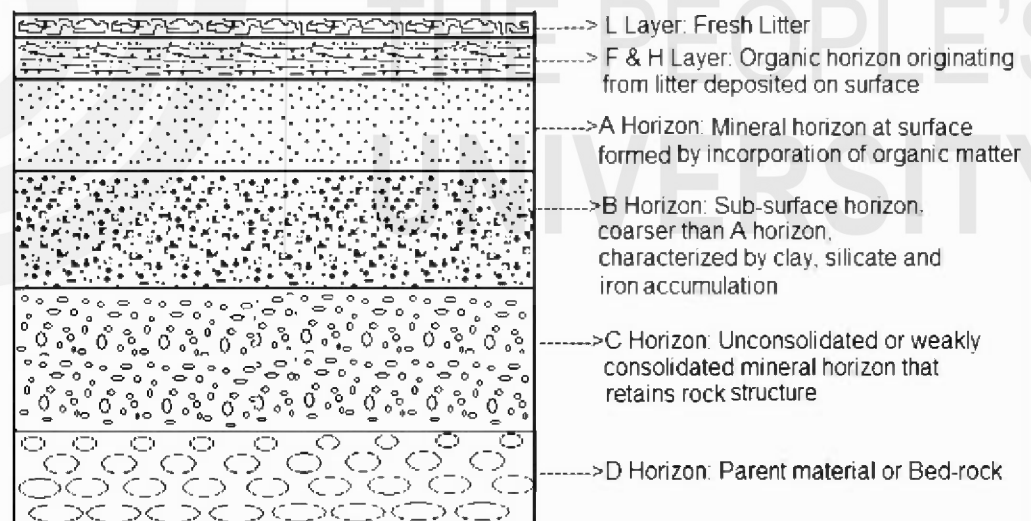


Fig. 2.1: Soil profile showing different soil horizons and parent material

A horizon is considered as top layer of mineral soil. It consists of the most intensively weathered rock material, being most exposed to surface processes. It also contains most of the organic matter. The upper portion of the A horizon is termed the topsoil, and under conditions of cultivation, the upper 12–25 centimeters (cm) is called the plow layer or furrow slice. This is followed by the layer of maximum leaching, known as the E horizon. In this horizon the water dissolves soluble minerals and carries them away with it. This process is known as leaching, and the A horizon is also termed the zone of leaching.

Many of the minerals leached from the A horizon accumulate in the layer below, the B horizon, also known as the zone of accumulation or deposition. Soil in the B horizon is coarser than the A-horizon soil because, it has been protected from the surface processes. Organic matter from the surface has also been less well mixed into the B horizon. Below the B horizon is a zone consisting principally of very coarsely broke-up bedrock and little else. This is the C horizon and does not resemble our usual idea of soil at all. Sometimes the bedrock or parent material itself is called D horizon.

2.6 SOIL COMPONENTS AND SOIL STRUCTURE

Four major components constitute soil viz., mineral matter, soil organic matter, water and air. The relative proportions of the four major components, mineral matter (40-60%), organic matter (<5%), water (20-50%) and air (10-25%), may vary widely. While mineral matter, water and gases are described in the following paragraphs, soil organic matter is described in separate section since, it bears special significances with respect to soil fertility.

The mineral matter derived from weathered rock consists of particles of different size. There is a continuous distribution of particle sizes in soil from boulders and stones down to fine clay particles. Soil that passes through a 2 mm sieve, the fine earth, is divided into sand, silt and clay. Soil texture denotes the relative proportions of sand, silt, or clay in a soil. Soils with the finest texture are called clay soils, while soils with the coarsest texture are called sandy soils. A soil that has a relatively even mixture of sand, silt, and clay is called loam. Finer textured soils tend to have greater ability to store soil nutrients.

While soil texture denotes the relative proportions of sand, silt, or clay in a soil, soil structure refers to the ways in which soil particles are arranged or grouped spatially. The groupings may occur at any size level ranging from single grained material like loose sand to massive aggregates like soil lump. Stabilization of soil aggregates is significant for soil fertility as it determine pattern of nutrient release from minerals. Stabilization is the result of various binding agents. A variety of other organic compounds act as binding agents, and some biological agents such as microbes, plant roots and fungi play a similar role.

Soil structure has strong implications for ecosystem management, particularly for Agroecosystems. A good soil structure provides a favourable environment for root growth and beneficial microbial activity. Soil structural quality can be measured in terms of available water capacity, aeration and water-stable aggregation. Deterioration of soil structure is revealed through inadequate soil aeration, decreased available water, impedance to root penetration because of soil compaction, and surface sealing.

Soil is a porous fabric that retains water and gases. Water is essential for sustaining life in soil as it mediates almost all the process supporting life in the biosphere. Soil water contains dissolved organic and inorganic solutes and is called the soil solution. Plants absorb this solution to get nutrients. While the soil air consists primarily of N_2 and O_2 , it usually contains higher concentrations of CO_2 than the atmosphere, and traces of other gases that are by products of microbial activity.

2.7 SOIL ORGANIC MATTER AND SOIL ORGANISMS

The organic matter of the soil arises from the debris of green plants, animal residues and excreta deposited on the surface and mixed to a variable extent with the mineral component. The dead organic matter is colonized by a variety of soil organisms, most importantly micro organisms, which derive energy for growth from the oxidative decomposition of complex organic molecules. The combination of living and dead organic matter, irrespective of its source or stage of decomposition (but excluding the living parts of plants above ground), is called soil organic matter (SOM).

During decomposition, essential elements are converted from organic combination to simple inorganic forms through a process called mineralization. The remainder of the substrate C used by the micro organisms is incorporated into their cell substance or microbial biomass, together with a variable proportion of other essential elements such as Nitrogen (N), Phosphorus (P) and Sulfur (S). This incorporation makes these elements unavailable for plant growth, until the organisms die and decay, so the process is called immobilization. Whether or not there is net immobilization or mineralization depends on the nature of the decomposing substrate and the species composition of the soil organisms. Generally, Carbon to Nitrogen (C: N) ratios > 20 favour an increase in microbial biomass and net immobilization of N, whereas C: N ratios < 20 favour net mineralization.

The various interlocking processes of synthesis and decomposition, by which C is circulated through soil, plants, animals and air, comprise the carbon cycle. For the past 200 years or so, the release of CO₂ from the combustion of fossil fuels, respiration by organisms, land clearing and burning has exceeded the sequestration of C in living and dead organisms on land and in water. This has led to a steady rise in the CO₂ concentration in the atmosphere. This is often described as the enhanced 'greenhouse effect'. Globally, soil organic matter is a very large sink of carbon. Hence, changes in the dynamic soil organic matter can significantly affect the net flux of CO₂ to the atmosphere.

Organic matter in soil performs several important functions. It helps to build up a loose soil structure with a large number of pores. This allows easier root penetration, better aeration and allows water to infiltrate more easily into the soil. The larger visible particles of organic matter act as tiny sponges in the soil (holding as much as five times their own weight in water); this can make sandy soils more drought tolerant. The smaller non visible particles act like glue sticking the soil particles together forming larger soil crumbs. This can improve the soil structure in clay and sandy soils. The organic matter acts as a food source for soil micro organisms and larger soil organisms; this allows the organic matter to decompose. The organic matter also provides a habitat for the soil organisms. The organic matter has a great capacity to retain nutrients and to release them continuously. This has the effect of increasing the nutrient supply to the plants and will reduce nutrient loss in the soil from leaching. This is important in sandy soils which have poor nutrient retention. Organic matter has a buffering capacity, preventing soils from becoming too acidic or alkaline.

Soil organisms, often termed as soil biota or below ground biodiversity, include archaea, bacteria, fungi, protozoans, algae and invertebrate animals. Among invertebrates, there are various taxonomic groups including nematodes, annelids, arthropods and mollusks. The diversity of these organisms is amazingly very high. According to recent estimations, soil organisms may represent over 2 million species or as much as 23% of the total diversity of living organisms that have been described till date. Soil organisms contribute significantly in terms of their body mass or nutrient in ecosystem. Earthworm biomass normally ranges from 5 to 3000 kg live weight per ha, whereas the microbial biomass makes up 2– 4% of the total organic C in soil, or 0.5–2 t C/ha.

The soil organisms play vital role in soil. They help decompose organic matter in the soil and produce humus. They mix the organic matter with soil particles and build up stable soil crumbs. They make tunnels in the soil opening up the soil to promote deeper rooting of the crop, and better aeration of the soil. They help to release nutrients from mineral particles in the soil. They can help to control pest and disease organisms which may affect the roots of the crop.

Check Your Progress 1

Note: a) Use the space given below for your answer.

b) Compare your answers with those given at the end of the unit.

1) How does mineralization differ from immobilization?

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2) What is the role of organic matter in soil?

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2.8 SOIL NUTRIENTS, SOIL FERTILITY AND SOIL QUALITY

There are 17 elements without which green plants cannot grow normally and reproduce. On the basis of their concentration in plants, these essential elements are subdivided into: the macronutrients C, H, O, N, P, S, Ca, Mg, K and Cl which occur at concentrations > 1000 mg/kg (plant dry matter basis); and the micronutrients Fe, Mn, Zn, Cu, B, Ni and Mo which are generally < 100 mg/kg. Out of different nutrients, C, H and O are supplied as CO₂ and H₂O, which are abundant in the atmosphere and hydrosphere; likewise Cl, which is abundant

and very mobile as the Cl⁻ ion. Of the others, with the exception of N which comprises 78% of the atmosphere, the major sources of the essential elements are weathering minerals in the soil and parent material.

Soil fertility is a connotation of the nutrient status or ability of soil to supply nutrients for plant growth under favourable environmental conditions such as light, temperature and physical conditions of soil. Fertile soil contains sufficient nutrients to ensure plant growth and yield and is able to maintain appropriate moisture and components in the soil. Soil fertility is the foundation of sustainable agriculture. Fertile or healthy soils have a shielding capacity that allows a balanced intake of nutrients and can improve water retention; thereby creating a healthy plant that is less susceptible to pest attack and will be more resistant to pest damage.

Often land productivity, as measured by the yield of crop or animal product per hectare soil, is taken as indicator of soil fertility. In fact, land productivity is governed by a number of other factors besides soil fertility. These factors include climate, pests, disease, genetic potential of the crop, and man's management. Soil fertility connotes primarily, the combined effect of chemical and biological properties, and is probably the most important single soil factor affecting land productivity.

Soil quality is another term which is used to specify soil attributes in more comprehensive sense. Soil quality is often defined as 'the capacity of a soil to function within ecosystem boundaries to sustain biological productivity, maintain environmental quality, and promote plant and animal health'. Conventionally soil quality and soil fertility have been used almost synonymously. However, in recent years, due to increasing concern for environmental protection across the globe, a more comprehensive description of soil quality is demanded. In fact soil is increasingly being recognized as a vital component of environment along with air and water.

Quality of soil is experienced directly or indirectly through the diversity and health of the natural ecosystems it supports, the quality and quantity of crops (and animals) grown, the water (and sometimes sediment) that runs off and drains from a soil, and the gases absorbed or released by a soil. Whereas the desirable qualities of air and water for human and animal life can be adequately defined and monitored, the same is not true of soil for several reasons. Soil is continuously variable in space and, being a complex, dynamic biological system, is variable in time. The rate of change of individual soil properties is itself very variable.

The quality of a soil depends on the soil's use and its fitness for that use or function. This premise underlies the assessment of land use capability (called land evaluation) in which land is classed according to its suitability for various uses. Agriculture has traditionally been a key use, and soil quality is a major factor determining the land capability class (ranging from the best class – no limitations, to the worst class – severe limitations). The land use capability approach has been adapted to determine the suitability of soils for a range of crops, usually based on a correlation between crop yield and a set of biophysical criteria (e.g. climate, soil physical properties, soil acidity and organic matter content) to derive a soil quality index.

The definition of soil quality becomes more specific, when contaminated land is considered. Soil contamination by organic and inorganic chemicals occurs in urban and rural areas from various causes such as: mining activities (including exploration, extraction and processing); industrial activities (including defence, and the disposal of industrial waste); urban living (including motor transport, and the concentration of urban waste through storm water runoff, sewage effluent and sewage sludge); and agriculture, forestry and horticulture, through over use of fertilizers and pesticides.

Although we ideally aspire to defining soil quality in objective terms, in reality the concept is diffuse and must reflect a range of social, cultural and economic factors as well as biophysical properties. For these reasons, soil quality is often assessed by the management practices that are designed to improve, or at least maintain, a soil's performance for specific purposes, e.g. minimizing erosion, supporting a variety of crops, storing good quality water under ground, or minimizing the movement of heavy metals applied in industrial wastes.

2.9 MANAGEMENT OF SOIL FERTILITY

Soil fertility management is a long term strategy aimed at reducing the loss of nutrients and building soil fertility through the continuous nourishment of the soil. The aim is to minimize the need, to bring in external inputs from outside the farm. In simple words, soil fertility management means methods of farming or agriculture. Soil management practices greatly vary across the countries and are guided by numerous factors including crop types, geography, climate, traditional practices, economic development, modernization etc.

Out of numerous soil fertility management practices, here we are describing organic agriculture as one model. Organic agriculture, sometimes described as 'biological farming,' has, in fact, emerged as an alternative to the conventional agriculture which is based on the use of chemicals for intensive production. Organic agriculture, which is more labour intensive as compared to conventional agriculture, is based on the adoption of several strategies, as crop rotation, conservation of biodiversity, use of organic manure, crop residues and green manure etc.

Crop rotation involves a planned succession of crops on each farm field to achieve control over weeds, diseases and insects, and to promote efficient nutrient cycling and good soil structure. By appropriate sequencing of crops and management of residues, the populations of natural predators of pest organisms can increase, allowing pesticide use to be scaled back. This concept is the basis of integrated pest management (IPM). By conserving biodiversity through rearing diversity of crops and livestock, farm income can be buffered against market, climatic and biological risks, in contrast to crop monoculture (e.g. cotton) or single enterprise animal farming (e.g. sheep for wool), where income is particularly vulnerable to fluctuations in commodity prices, extremes of weather and the incidence of pests and disease.

By the use of organic manures and crop residues to a soil, nutrient cycling is improved and soil organic matter is maintained or increased. The later effect is beneficial for soil structure, increases water infiltration and storage, and improves soil tilth. Good tilth promotes seed germination and seedling emergence. Organic

matter encourages soil micro organisms and soil fauna, especially earthworms. Green manures are especially important in organic farming, not only for the return of residues, but also for the incorporation of legumes that contribute N_2 fixed from the air. Green manuring is often advocated to prevent leaching of surplus soil NO_3^- during winter or the non cash crop period.

2.10 AGRICULTURE, SOIL QUALITY AND SUSTAINABILITY

Since humans are terrestrial creatures and largely dependent on land based food resources, their survival on the planet, to a great extent depends on maintenance of fertility of soil to grow enough food for the huge population of over 6.5 billion people. Already only 10% area of the total land is under cultivation and that too has deteriorated in the past several decades due to faulty agricultural practices. Concern over soil health remained in focus in global development issues such as food security, land degradation and the provision of ecosystem services.

Traditional farming practices, based on rotational cropping, mixed farming and use of farm yard manure, were generally sustainable over a long period in past. However, because of population pressure, the cost of labour and the demand for land for non-agricultural use, traditional methods have gradually been displaced by intensive mono cultural systems, such as continuous cereal cropping, and livestock farming. This trend has resulted in varying degrees of soil nutrient depletion, soil structural decline, salinization, accelerated acidification, erosion and overall environmental degradation in many countries. Modern intensive farming requires substantial inputs of fertilizers and organic manures to maintain soil fertility.

For the last 60 years, demand for food, fibre and forest products from an escalating world population has led to increased use of fertilizers to improve yields, and pesticides to control pests and diseases. Such practices have resulted in some accumulation of undesirable pesticide residues in soil, and in increased losses of soluble constituents such as nitrate and phosphates to surface waters and groundwater. For example, nitrate when applied to agricultural land in excess amount leaches from soil and mixes in ground water. When this water is used to make bottled-milk feed for babies, it leads to methaemoglobinaemia or 'blue-baby disease among infants. Similarly agricultural run-off containing nitrates and phosphate causes eutrophication of lakes and ponds.

The ideal pesticide is one, that controls only the target organism and persists long enough to achieve this purpose before degrading into harmless products. In practice, however, the ideal is not always achieved and chemicals have been used in agriculture that are 'broad spectrum' in their activity; that is, they kill harmless and beneficial organisms as well as the target organisms. Pesticides, such as the organochlorine, are very stable and have high lipid solubility. They therefore, accumulate in the fatty tissues of animals. Extensive use of these and other persistent chemicals has led to their residues and breakdown products becoming widely disseminated, and there have been many instances of their detrimental effect on beneficial insects and plants, domestic animals and wildlife.

More recently, however, scientists, producers and planners have acknowledged the need to compromise between maximizing crop production and conserving a

valuable natural resource. As a response to these concerns, organic agriculture is emerging as an alternative to the conventional agriculture. Emphasis is now placed on maintaining the soil's natural condition by minimizing the disturbance when crops are grown, matching fertilizer additions more closely to crop demand in order to reduce losses, using legumes to fix N_2 from the air, and returning plant residues and waste materials to the soil to supply some of a crop's nutrient requirements.

Precision agriculture has evolved as response, to prevailing challenge of nutrient imbalance in soil. In this agriculture, instead of 'blanket' recommendations for a nutrient for a particular field, fertilizer applications can be adjusted to the specific need of parts of individual fields, based on crop yield maps or spatially referenced data for soil tests. Similar to precision agriculture, new tillage methods have been designed to maintain soil structure and minimize erosion losses. They have gained widespread popularity, compared mainly on soils, where high surface temperatures, high evapotranspiration, surface sealing, and water and wind erosion pose problems. These methods range from reduced or minimum tillage (fewer passes with cultivating implements) to direct drilling or no-till, where the only disturbance is injecting fertilizers and sowing seeds.

There are still great lacunae in our current understanding about optimal use of soil resources and sustainability implications of various land management practices. Nevertheless, with the continuous research work in agricultural and associated sciences, a number of soil fertility management strategies are being evolved, tested and implemented by scientists, planners and farmers across the globe to maintain a balance between economic gains and environmental quality.

2.11 SOIL TYPES IN INDIA

India has a wide range of soils, each type being particular of a specific locality. The Indian Council of Agricultural Research (ICAR) has made major contributions on the study of Indian soils. As per ICAR, Indian soils can be broadly grouped in eight categories, namely, alluvial soil, black soil, red soils, laterite soil, forest & mountain soils, arid & desert soils, saline & alkali soils and peaty & marshy soils.

Alluvial soils cover about 24% of the total land of India. They occupy most of the Indo-Gangetic Plains (from Punjab to West Bengal) and also occur in the valleys of Narmada and Tapi in Madhya Pradesh & Gujarat, Mahanadi in Orissa, Godawari in Andhra Pradesh and Cauvery in Tamilnadu. These soils are formed by the deposition of fine sediments and silt carried by the rivers along their banks. These soils respond well to irrigation and manuring. They are good for both rabi and kharif crops and suitable for wheat, sugarcane, rice, cotton and oilseeds. In delta region, they are ideal for jute cultivation. The economics of India, Pakistan and Bangladesh are dependent on alluvial soils.

The black cotton soils cover about 16% of the total land. These soils are found in the States of Maharashtra, Gujarat, Madhya Pradesh, Karnataka, Andhra Pradesh, Tamil Nadu, Uttar Pradesh and Rajasthan. These soils have been formed due to the weathering of the lava rocks. This is also known as the Regur soil and Cotton soil. These soils are rich in lime, iron, magnesia and alumina but lack in the phosphorus, nitrogen and organic matter. These are ideal for cultivation of cotton

and also good for cultivation of cereals, pulses, oil seeds, citrus fruits, vegetables, etc.

Red soils have been estimated to occur in about 16% of the total land. These soils are found in Chhotanagpur plateau, Telangana, Nilgiris, Tamil Nadu, Karnataka, Andhra Pradesh and periphery areas of Deccan Plateau. Red soils are reddish in colour due to the presence of iron. These soils have been formed due to decomposition of underlying igneous rocks under heavy rainfall. They have less humus. These are suitable for the cultivation of millets, pulses, linseed, tobacco etc.

Laterite soils occur in about 4% of the total land. These soils are formed under conditions of high temperature and heavy rainfall with alternate wet and dry periods. Laterite soils are found in elevated areas which receive very high rainfall. As a result of heavy rainfall, top soil gets washed away. This process is called leaching. The soil, therefore, loses its fertility to a great extent. These soils are found in the north-eastern state in India. Their colour is red due to the presence of iron oxide which is formed by leaching. These soils are good for cultivation of tea, coffee, rubber, cinchona and coconut.

Forest and mountain soils are mainly found on the hill slopes covered by forests. The formation of these soils is mainly governed by the characteristic deposition of organic matter derived from forest growth. In the Himalayan region, such soils are mainly found in valley basins, depressions and less steeply inclined slopes. Apart from the Himalayan region, the forest soils occur in higher hills in south and the peninsular region. Very rich in humus but are deficient in potash, phosphorous and lime and needs fertilizers. These are good for plantation of tea, coffee, spices, tropical fruits and vegetables.

The arid and desert soils occupy about 11% of the total land. These soils are found in dry areas of Rajasthan, Gujarat, Punjab, and Haryana. These soils are chiefly found in areas receiving less than 50 cm of annual rainfall and hence these are affected by desert conditions. These areas are covered by a mantle of sand which inhibits soil growth. These coarse soils are suitable for cultivation of jowar, bajara, cotton etc.

Soils with high proportion of salts and alkalis are called saline and alkali soils. They are formed due to accumulation of tidal water in adjoining coasts where drainage is poor. They are also found in drier parts of Bihar, Rajasthan, U.P., Punjab, Haryana, Maharashtra. These soils contain many salts like sodium, magnesium and calcium which make them infertile and render unfit for agriculture.

Marshy and peaty soils are found in continuously water-logged areas, or marshy areas. These originate in the humid regions as a result of accumulation of large amounts of organic matter in the soil. They contain considerable amounts of soluble salts and 10 to 40% of organic matter. These soils are found in some parts of Kerala, Bihar, Orissa, Tamil Nadu, West Bengal and UP.

Check Your Progress 2

- Note:** a) Use the space given below for your answer.
b) Compare your answers with those given at the end of the unit.

1) What is the difference between soil fertility and soil quality?

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2) What are the major impacts of conventional agriculture on soil health?

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2.12 LET US SUM UP

- Soil is technically defined as the layer of unconsolidated particles derived from weathered rocks, organic material, water and air that supports plant growth. A combination of physical, chemical and biotic forces acts on weathered rock and organic materials to produce soil.
- Four major components constitute soil viz., mineral matter, soil organic matter, water and air. The relative proportions of the four major components, however, vary widely. Soil organic matter plays important role in maintaining soil fertility.
- Soil fertility is a connotation of the nutrient status or ability of soil to supply nutrients for plant growth under favourable environmental conditions.
- Soil fertility management is a long term strategy aimed at reducing the loss of nutrients and building soil fertility through the continuous nourishment of the soil.
- More recently scientists, producers and planners have acknowledged the need to compromise between maximizing crop production and conserving a valuable natural resource.
- India has a wide range of soils. Eight major soil types have been identified by ICAR. Each type has certain characteristic features.

2.13 KEY WORDS

- Weathering** : Break down of rocks into smaller fragments that ultimately form soil.
- Eutrophication** : Excessive growth of algae and weeds in water-bodies due to high concentration of nutrients.
- Pedogenesis** : Process of formation of soil from rocks.
- Leaching** : Dissolving of minerals in water and their escape from that soil layer.
- Soil erosion** : Gradual removal of particles from soil leading to thinning of soil column.
- Ecosystem** : A piece of vegetated land or water-body where life can continue without external support.

2.14 REFERENCES AND SUGGESTED FURTHER READINGS

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Relevant Websites:

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- <http://www.isric.org/>
- <http://india.gov.in/citizen/agriculture/soil.php>
- <http://www.iiss.nic.in/index.html>
- <http://www.eoearth.org/article/Soil>
- <https://www.soils.org/publications/soils-glossary/>

2.15 KEY TO CHECK YOUR PROGRESS

Check Your Progress 1

- 1) Your answer must include the following points:
 - Mineralization means conversions of elements from organic combinations to simple inorganic forms
 - Immobilization means incorporation of elements by microorganisms in their cell

2) Your answer must include the following points:

- It helps to build up a loose and son soil structure with a large number of pores
- It acts as a food source for soil micro -organisms and larger soil organisms.

Check Your Progress 2

1) Your answer must include the following points:

- Soil fertility connotes ability of soil to supply nutrients for plant growth
- Soil quality connotes soil attributes in more comprehensive sense

2) Your answer must include the following points

- This resulted in varying degrees of soil nutrient imbalance
- Pesticide residue present in soil and ecosystem



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